Good morning!

This week, Friday is on Monday schedule!

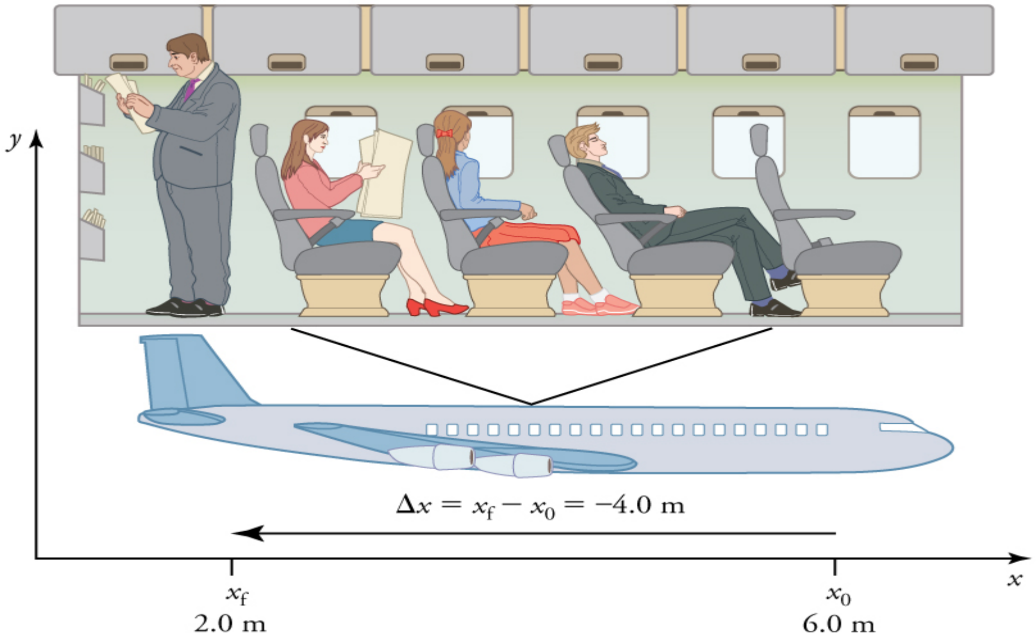
Please, sign in, login into webassing, locate LectureMCQ_L6 (PY105) and answer question 1 (but ONLY Q1 !)

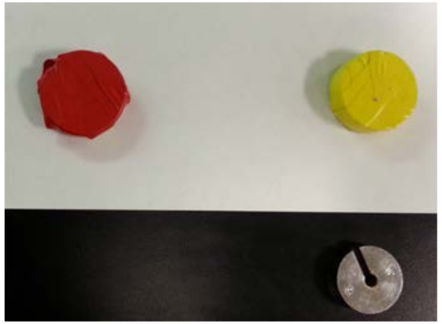
NOTE: Exam 1 is on Monday, June 4, 8:30 – 10:30 am, in LSE B01

Hint: arrive ~ 8-15

Lab3 is in SCI 134

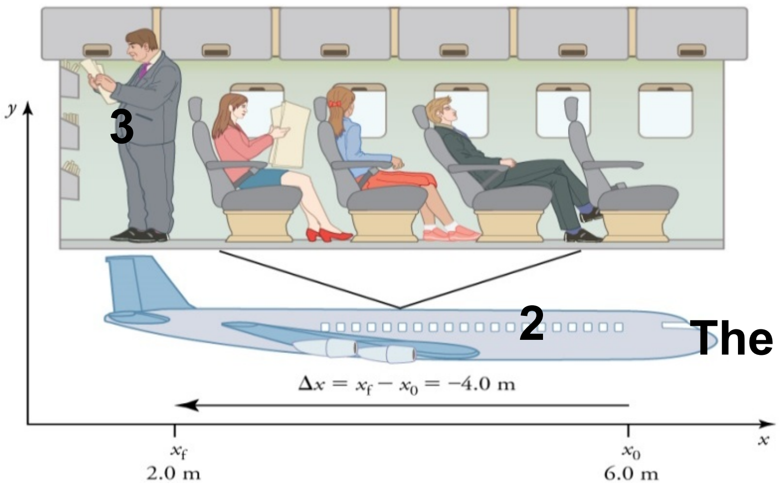
Relative motion, velocity addition, “crossing a river”.





Relative displacement

The passenger



The airplane

1

The ground

$$\Delta\vec{r}_{pg} = \Delta\vec{r}_{pP} + \Delta\vec{r}_{Pg}$$

Specific equation

$$\Delta\vec{r}_{31} = \Delta\vec{r}_{32} + \Delta\vec{r}_{21}$$

General equation

For ANY 3 objects

Relative velocity

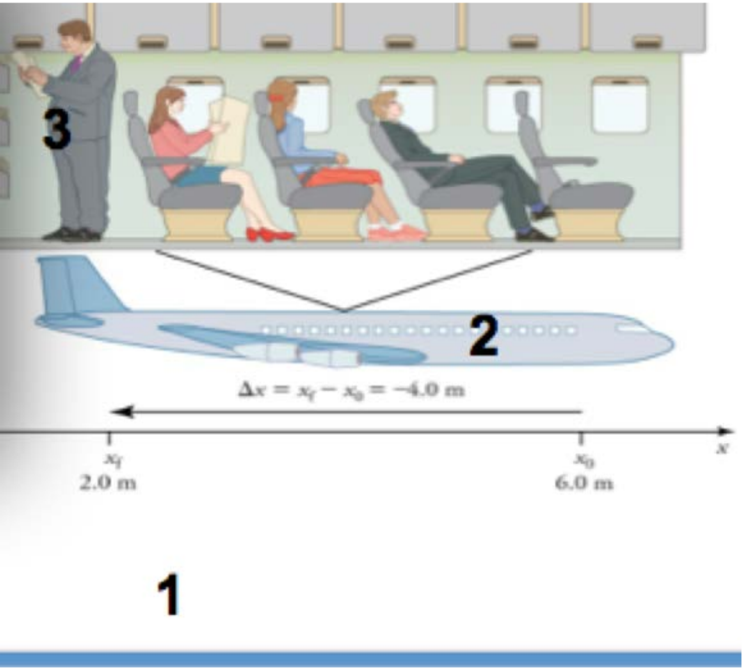
$$\frac{\Delta \overrightarrow{r_{31}}}{\Delta t} = \frac{\Delta \overrightarrow{r_{32}}}{\Delta t} + \frac{\Delta \overrightarrow{r_{21}}}{\Delta t}$$

or

General equation

$$\vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

For ANY 3 objects



The law of relative velocities (LRV)

Specific equation

$$\vec{v}_{pg} = \vec{v}_{pP} + \vec{v}_{Pg}$$

Relative velocity

The law of relative velocities (LRV)

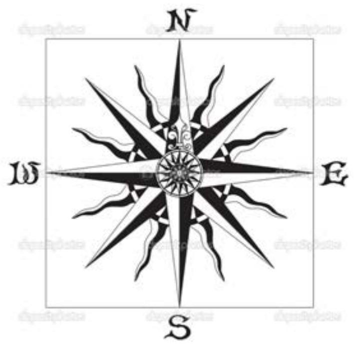
For ANY three objects

$$\vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

LEARNED! => Practice!

CP2

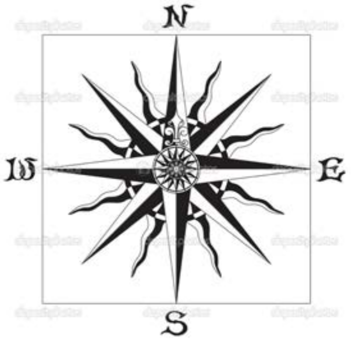
A passenger moves 4 m west <u>relative to the airplane</u>. If over the same time the plane moved 300 m east <u>relative to the ground</u>, what is the displacement of the passenger relative to the ground?



The displacement of the passenger relative to the ground points   1. East   2. West

$$\Delta\vec{r}_{31} = \Delta\vec{r}_{32} + \Delta\vec{r}_{21}$$

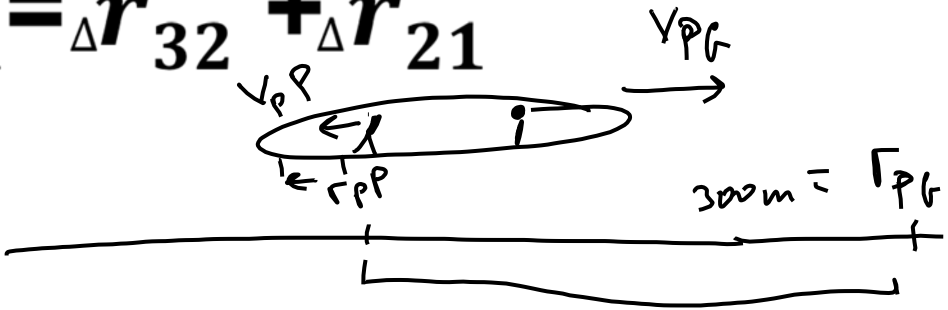
A passenger moves 4 m west <u>relative to the airplane</u>. If over the same time the plane moved 300 m east <u>relative to the ground</u>, what is the displacement of the passenger relative to the ground?



LectureMCQ_L6_Q2

The displacement of the passenger relative to the ground points 1. East 2. West

$$\Delta\vec{r}_{31} = \Delta\vec{r}_{32} + \Delta\vec{r}_{21}$$



$\Delta\vec{r}_{pG} = \Delta\vec{r}_{pP} + \Delta\vec{r}_{PG} =$

CP3

A training plane makes a round trip. First it flies 112 km East and then it flies right back. On its way due East a pilot sees a cloud and he measures that the speed of the cloud is 300 m/s. He also knows that according to the weather report, a strong wind due East with the speed of the wind relative to the ground 20 m/s has been blowing during the whole trip.

How long was the trip?

A training plane makes a round trip. First it flies 112 km East and then it flies right back. On its way due East a pilot sees a cloud and he measures that the speed of the cloud is 300 m/s. He also knows that according to the weather report, a strong wind due East with the speed of the wind relative to the ground 20 m/s has been blowing during the whole trip. How long was the trip?

$\longrightarrow V_{PC} = 300$ m/s $\longrightarrow V_{CG} = 20$ m/s

$L = 112$ km $= 112\,000$ m

$|V_{PG}| = 300 + 20 = 320$ m/s

$t_E = \frac{L}{v} = \frac{112000}{320}$

1 2

$\vec{V}_{12} = -\vec{V}_{21}$

$\vec{V}_{31} = \vec{V}_{32} + \vec{V}_{23}$

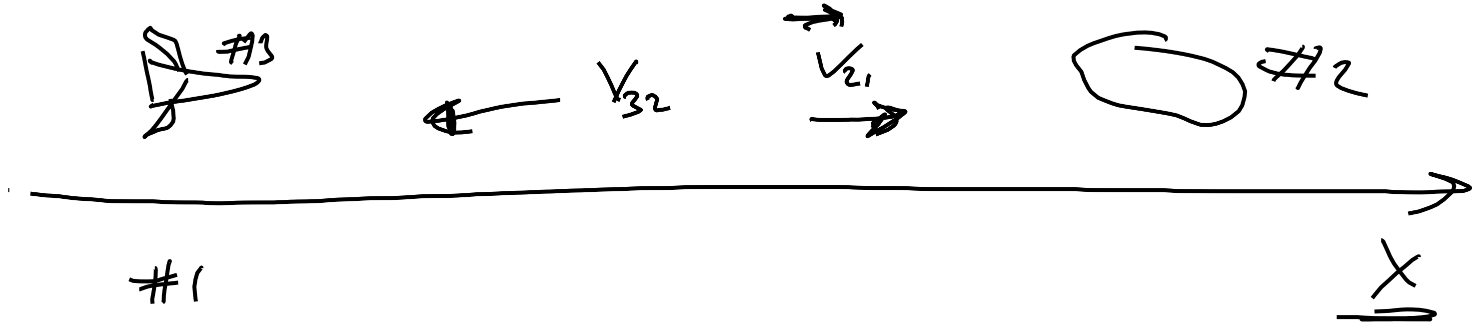
$V_{PC} = 300$ m/s $\longleftarrow$

$\longrightarrow V_{CG} = 20$ m/s

$L = 112\,000$ m

$|V_{PG}| = 300 - 20 = 280$ m/s

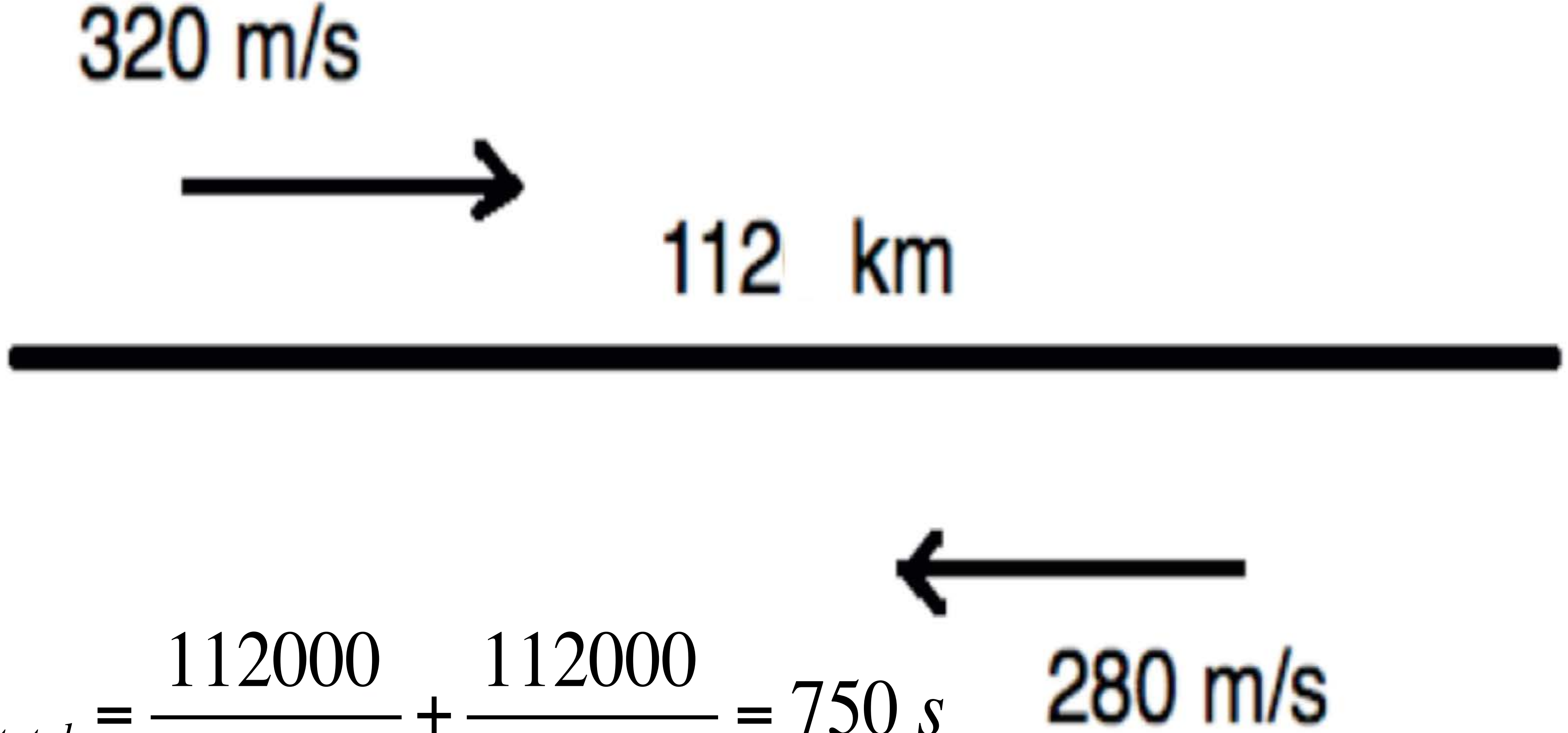
$t_W = \frac{112000}{280}$



$$\vec{V}_{31} = \vec{V}_{32} + \vec{V}_{21}$$

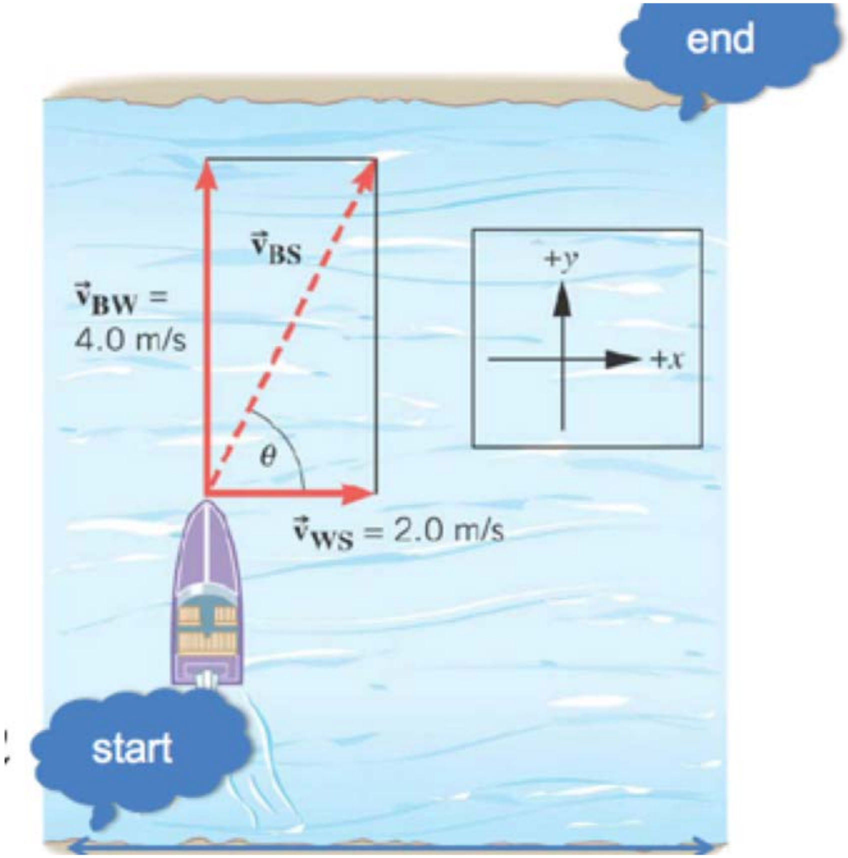
$$X: \quad \underline{V_{31x}} = V_{32x} + V_{21x} = -300 + 20 = -280 \text{ m/s}$$

$$|V_{31}| = 280 \text{ m/s}$$



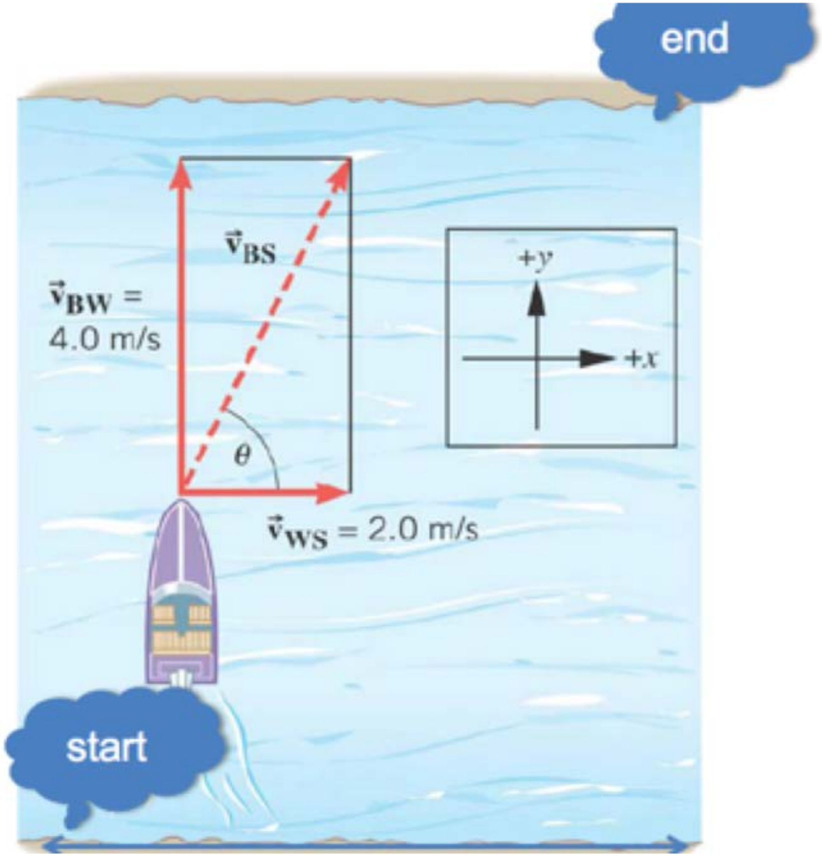
$$t_{total} = \frac{112000}{300+20} + \frac{112000}{300-20} = 750\ s$$

Crossing the river



CP2

Crossing the river



$$\vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

$$\Delta\vec{r}_{31} = \Delta\vec{r}_{32} + \Delta\vec{r}_{21}$$

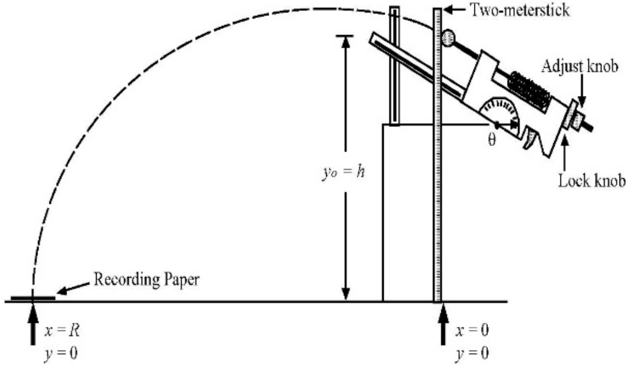
LEARNED!

CP3

2- Dimensional motion

An ACTUAL!

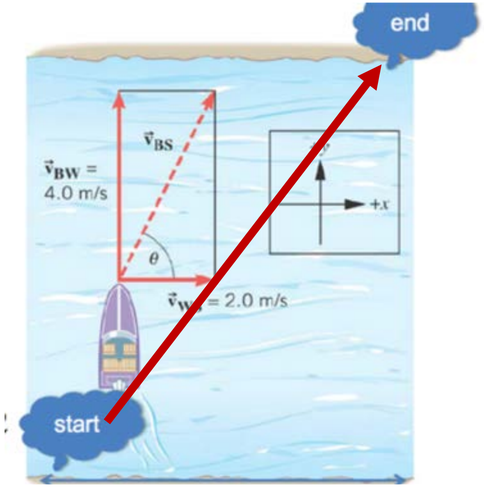
Trajectory *CANNOT* be a straight line



For example:
projectile motion

By the CHOICE!

Trajectory *CAN* be a straight line



For example:
crossing the river

You have a boat and you're trying to cross a river (that has parallel banks) *by the shortest path*. If there was no current in the river (e.g. a lake!), the shortest path would be achieved by aiming your boat directly across the river. But in the river the stream affects the boat. How should you *aim* your boat in a river to reach the far shore *by the shortest path*?

The *shortest distance*?

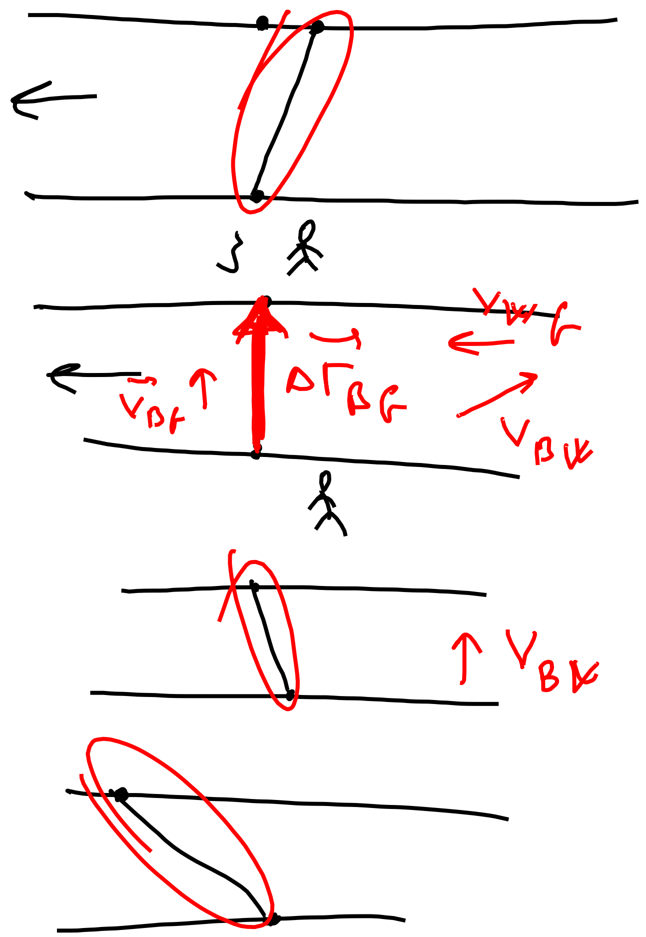
LectureMCQ L6 Q3

(1) *Angle* the boat upstream, and go against the current, landing somewhere upstream.

(2) *Aim* the boat upstream in such a way that you land at the point directly across from where you started.

(3) *Point* your boat directly across the river and get carried some way downstream.

(4) *Direct* your boat downstream and get carried even further downstream.



You have a boat and you're trying to cross a river. How should you aim your boat to reach the far shore and cover the ***shortest distance***? https://www.youtube.com/watch?v=za1Dyi1f3JI

(1) Angle the boat upstream, and go against the current, landing somewhere upstream.

(2) Angle the boat upstream in such a way that you land at the point directly across from where you started.

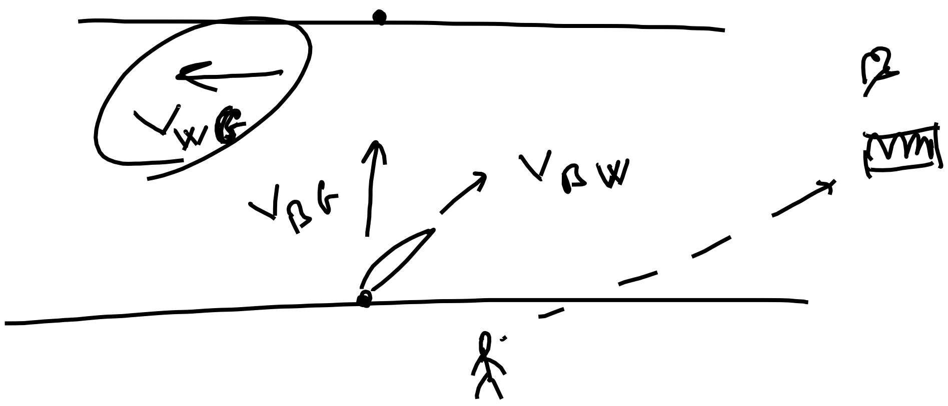
(3) Point your boat directly across the river and get carried some way downstream.

(4) Angle your boat downstream and get carried even further downstream.

If the current in the river is 3 *m/s* and your boat travels in a lake at 5 *m/s*, how should you aim your boat so you land at the point directly across the river?

If the river is 100 m wide, how long does it take you to cross?

If the current in the river is 3 *m/s* and your boat travels in a lake at 5 *m/s*, how should you aim your boat so you land at the point directly across the river? If the river is 100 m wide, how long does it take you to cross?



$$\vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$$

$\cancel{8 = 5 + 3}$ WRONG!

$|V_{WG}| = 3\ m/s$

$|V_{BW}| = 5\ m/s$

$|V_{BG}| = ?$

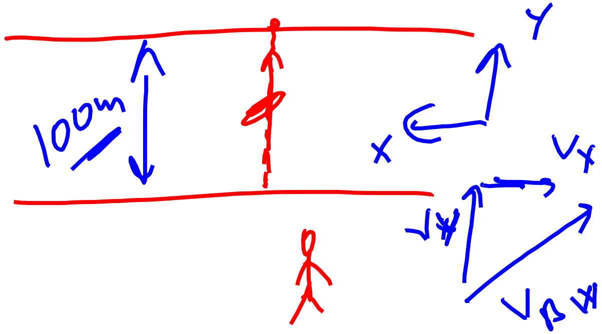
CP2/3

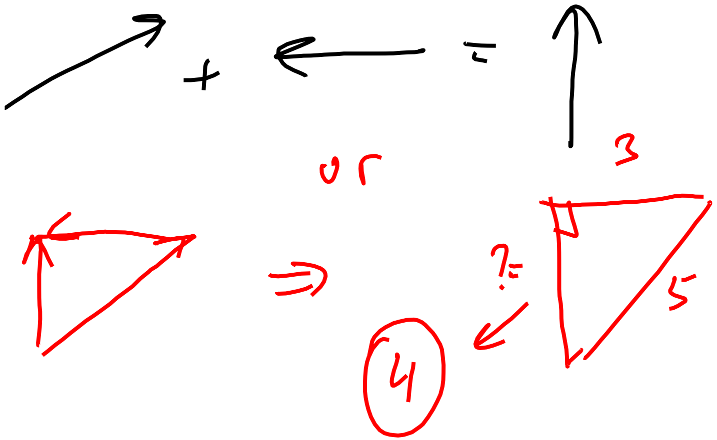
$V_{wr} = 3\,m/s$

$V_{Br} = ?$

$V_{Bw} = 5\,m/s$

$\vec{V}_{Br} = \vec{V}_{Bw} + \vec{V}_{wr}$





$V_{Br} = \frac{\Delta r}{T}$

$T = \frac{100}{4} = 25\,s$

You have a boat and you're trying to cross a river (that has parallel banks) *in the shortest time*. If there was no current in the river (e.g. a lake!), the quickest way to cross would be to aim your boat directly across the river. But in the river the stream affects the boat. How should you aim your boat in a river to reach the far shore in ***the shortest time*?**

the shortest time

➡

You you're trying to cross a river that has parallel banks. How should you aim your boat to reach the far shore in *the shortest time*?

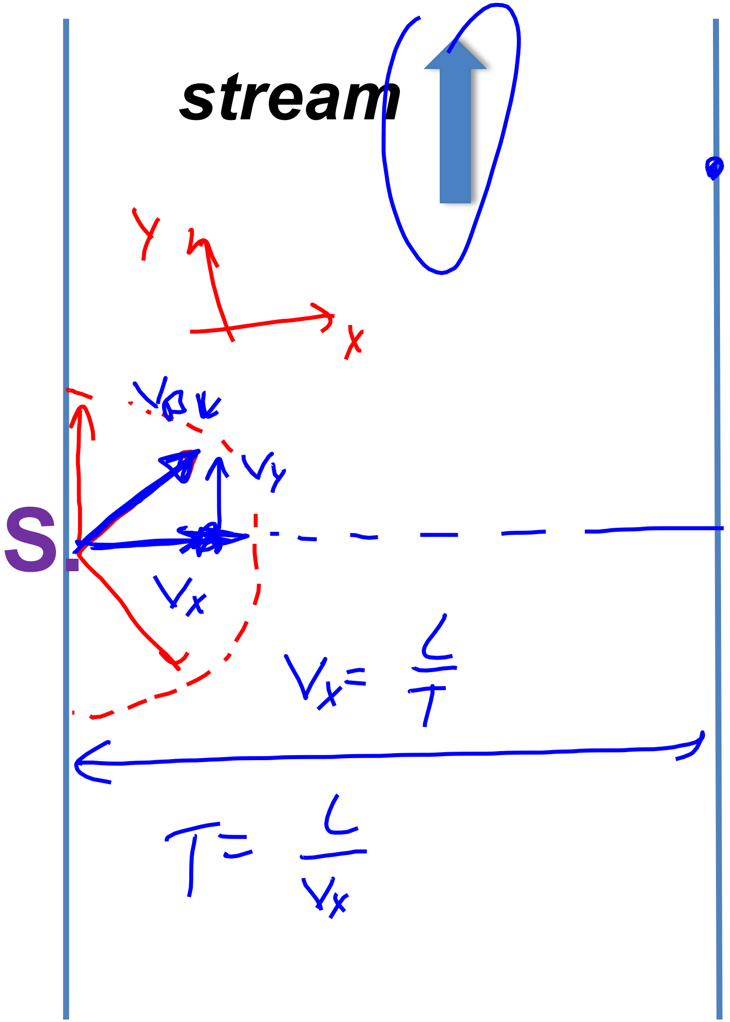
(1) *Angle* the boat upstream, and go against the current, landing somewhere upstream.

(2) *Aim* the boat upstream in such a way that you land at the point directly across from where you started.

(3) *Point* your boat directly across the river and get carried some way downstream.

(4) *Direct* your boat downstream and get carried even further downstream.

LectureMCQ L6 Q4



You have a boat and you're trying to cross a river that has parallel banks. If there was no current in the river (in a lake!), the *quickest* way to cross is to aim your boat directly across the river. But in the river the stream affects the boat. How should you aim your boat to reach the far shore in ***the shortest time***?

The ASNWER is

(1) Angle the boat upstream, and go against the current, landing somewhere upstream.

(2) Angle the boat upstream in such a way that you land at the point directly across from where you started.

(3) Point your boat *directly across* the river and get carried some way downstream.

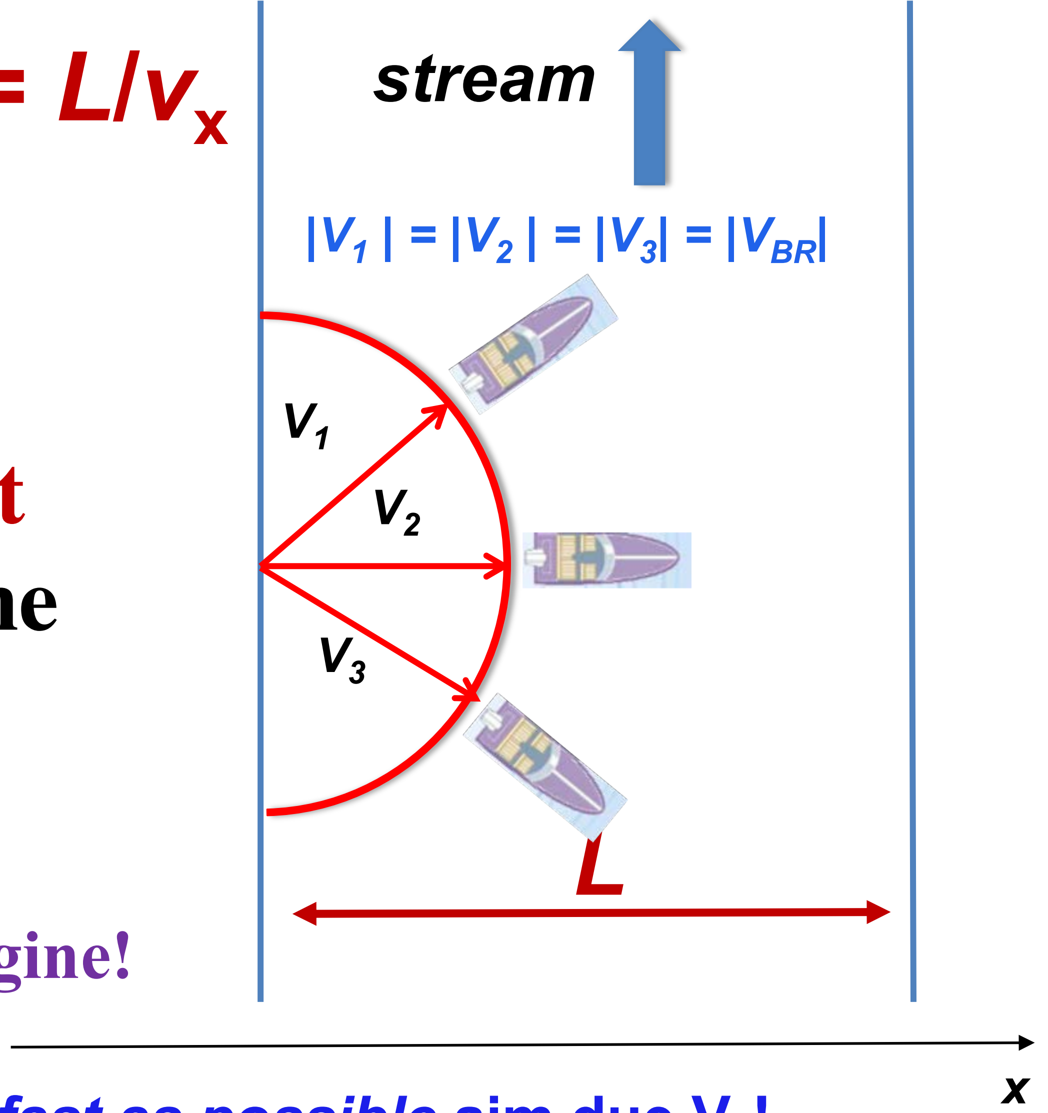
(4) Angle your boat downstream and get carried even further downstream.

Time depends on V_x ! $t_{cross} = L/v_x$

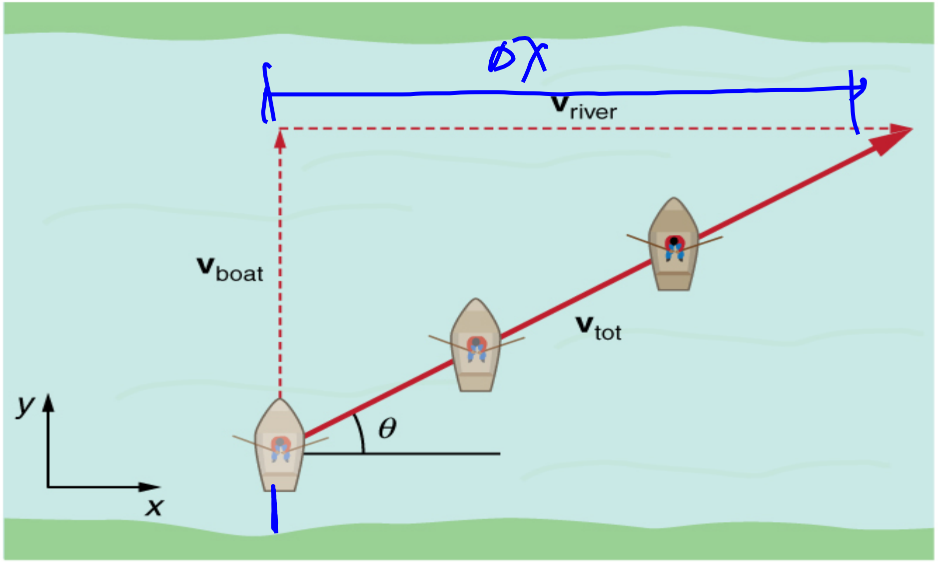
Out of ALL possible velocities of a boat relative to the water (but with the same magnitude) the fastest crossing (shortest time) done by the one with the longest x-component!

=> V_2 !

Speed is fixed by the engine!



To cross *as fast as possible* aim due V_2!



$$\vec{v}_{BS} = \vec{v}_{BW} + \vec{v}_{WS}$$

A person heading straight across a river will actually move diagonally relative to the shore as shown. Its total velocity (solid arrow) relative to the shore is the sum of its velocity relative to the river plus the velocity of the river relative to the shore.

This gives the *fastest* way to cross the river!

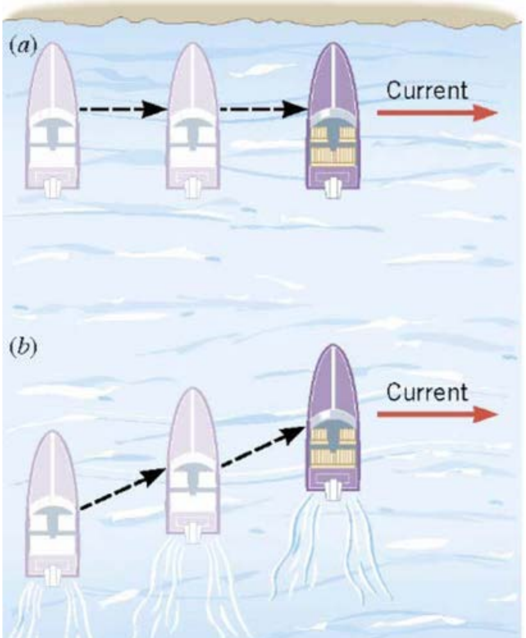
Crossing a River (the fastest trip)

The engine of a boat drives it across a river that is 1800 m wide. The velocity of the boat relative to the water is 4.0 m/s and directed perpendicular to the current. The velocity of the water relative to the shore is 2.0 m/s.

(a) What is the velocity of the boat relative to the shore ($|v|$, and Θ)?

(b) How long does it take for the boat to cross the river?

(c) How far (along the shore) is the landing point from the start?



(Adopted from College Physics by Cutnell and Johnson)

You are crossing a river that is 1800 m wide. The velocity of your boat in a lake would have been 4.0 m/s. The velocity of the water relative to the shore is 2.0 m/s. You want to cross the rive as fast as possible.

(a) What is the velocity of the boat relative to the shore (|*V*|, and *Θ*)?

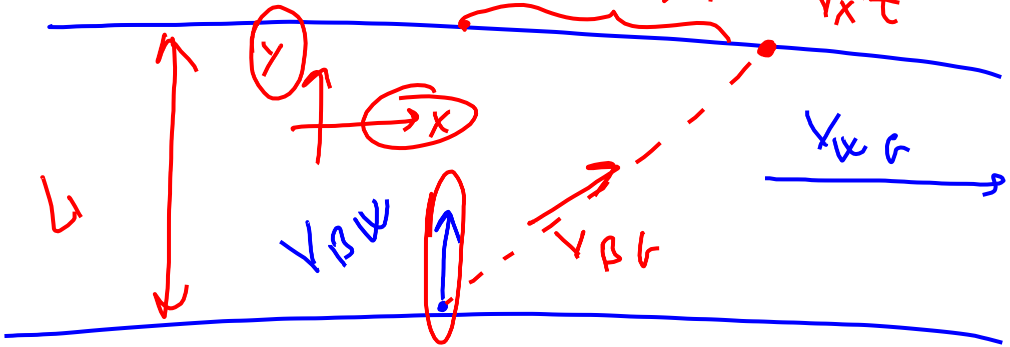
(b) How long does it take for the boat to cross the river?

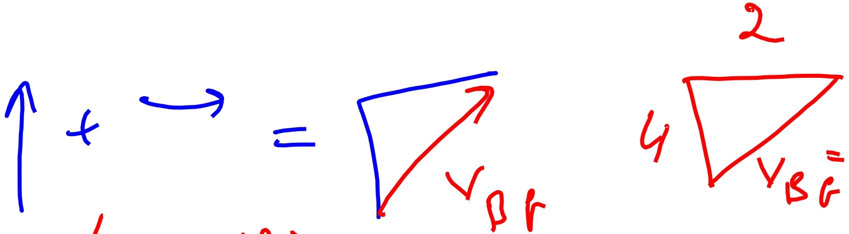
(c) How far (along the shore) is the landing point from the start?

$\vec{V}_{BW} + \vec{V}_{WG} = \vec{V}_{BG}$

CP

$\Delta x = V_x \cdot t$



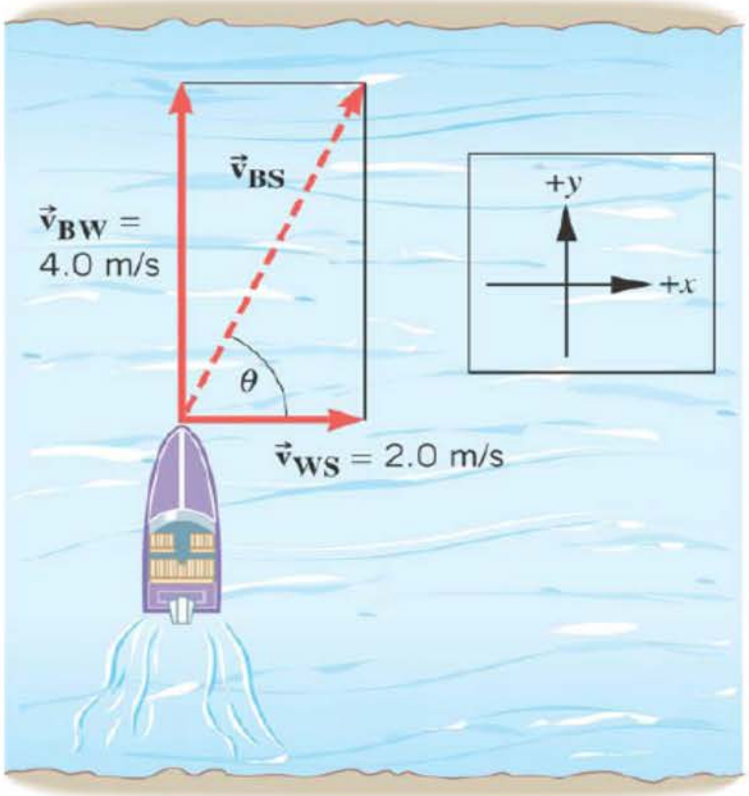


$V_{BG} = \sqrt{2^2 + 4^2}$

$t = \frac{L}{V_{BW}} = \frac{1800}{4}$ s

$$\vec{\mathbf{v}}_{\mathbf{BS}} = \vec{\mathbf{v}}_{\mathbf{BW}} + \vec{\mathbf{v}}_{\mathbf{WS}}$$

boat **shore** **water**

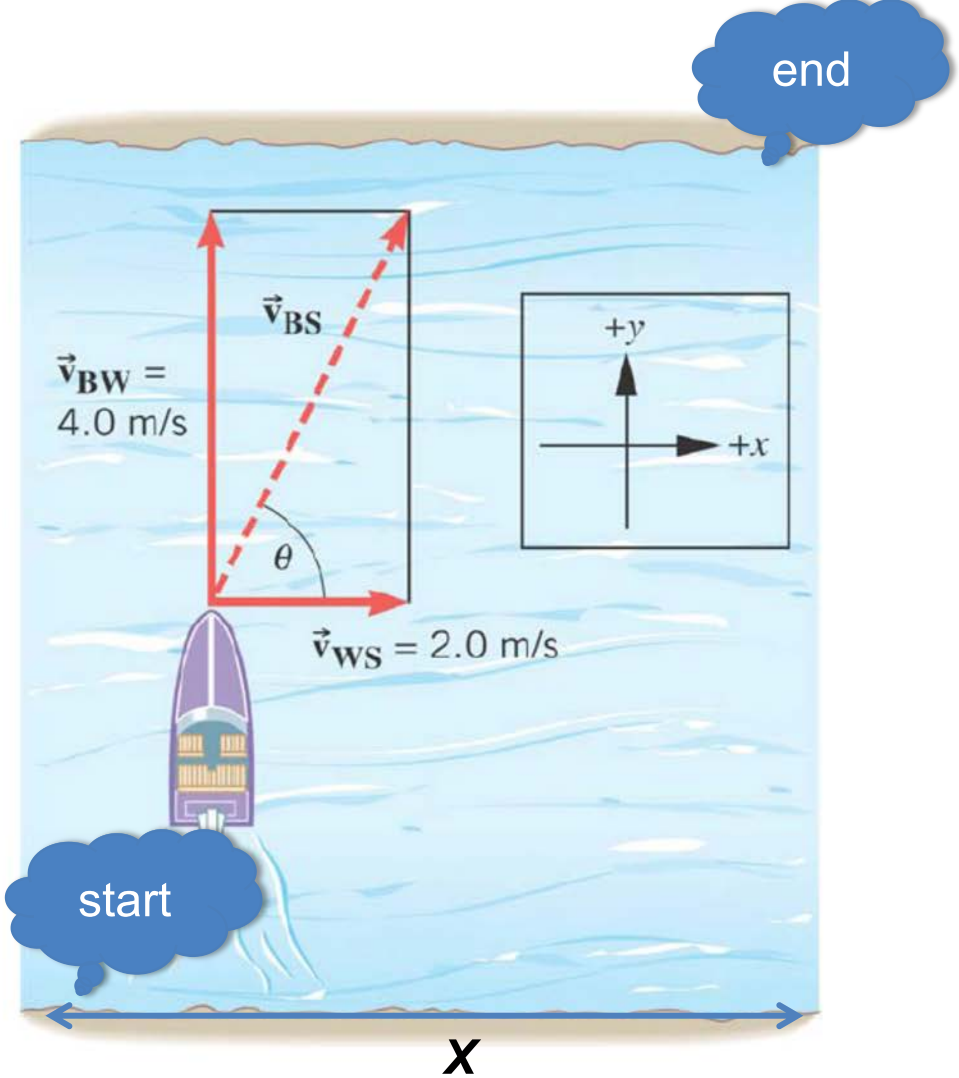


$$\theta = \tan^{-1}\left(\frac{4.0}{2.0}\right) = 63^\circ$$

$$v_{BS} = \sqrt{v_{BW}^2 + v_{WS}^2} = \sqrt{(4.0\,\mathrm{m/s})^2 + (2.0\,\mathrm{m/s})^2}$$
$$= 4.5\,\mathrm{m/s}$$

$$t = \frac{1800\ \text{m}}{4.0\ \text{m/s}} = 450\ \text{s}$$

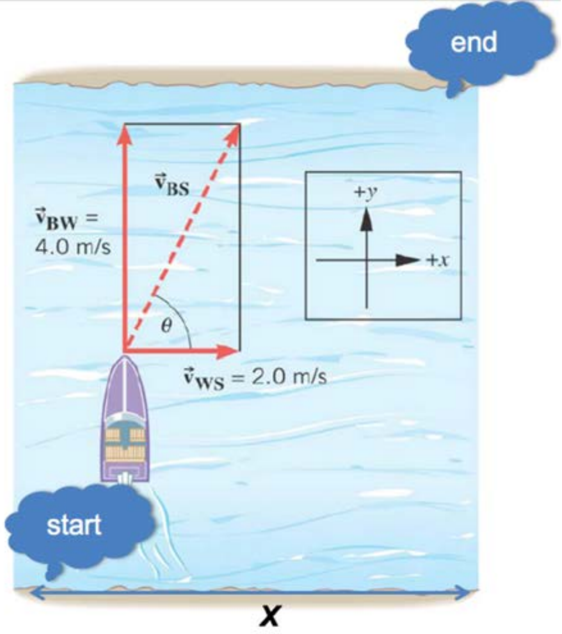
$$X = 2 * 450 = 900\,m$$



Can you find the *distance traveled*?

$$t = \frac{1800\ \mathrm{m}}{4.0\ \mathrm{m/s}} = 450\ \mathrm{s}$$

$$X = 2 * 450 = 900\, m$$



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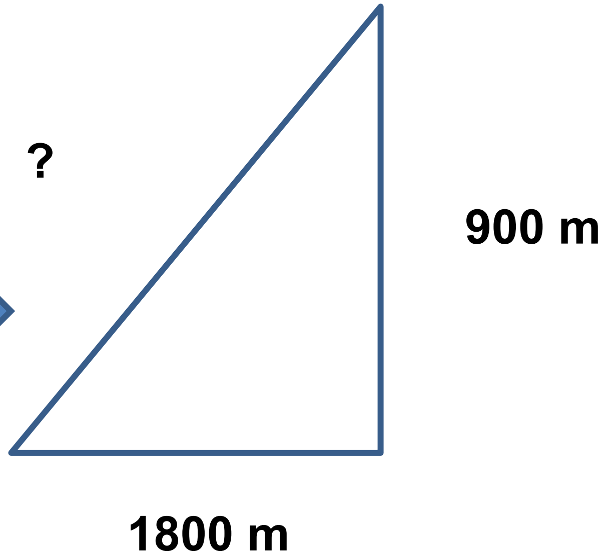
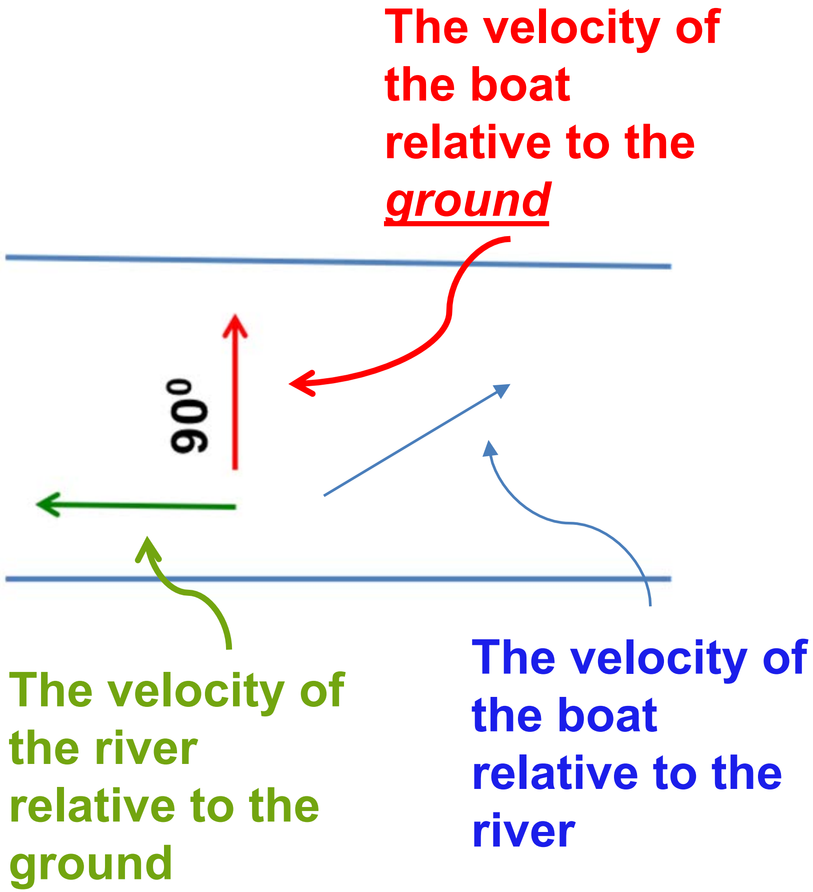
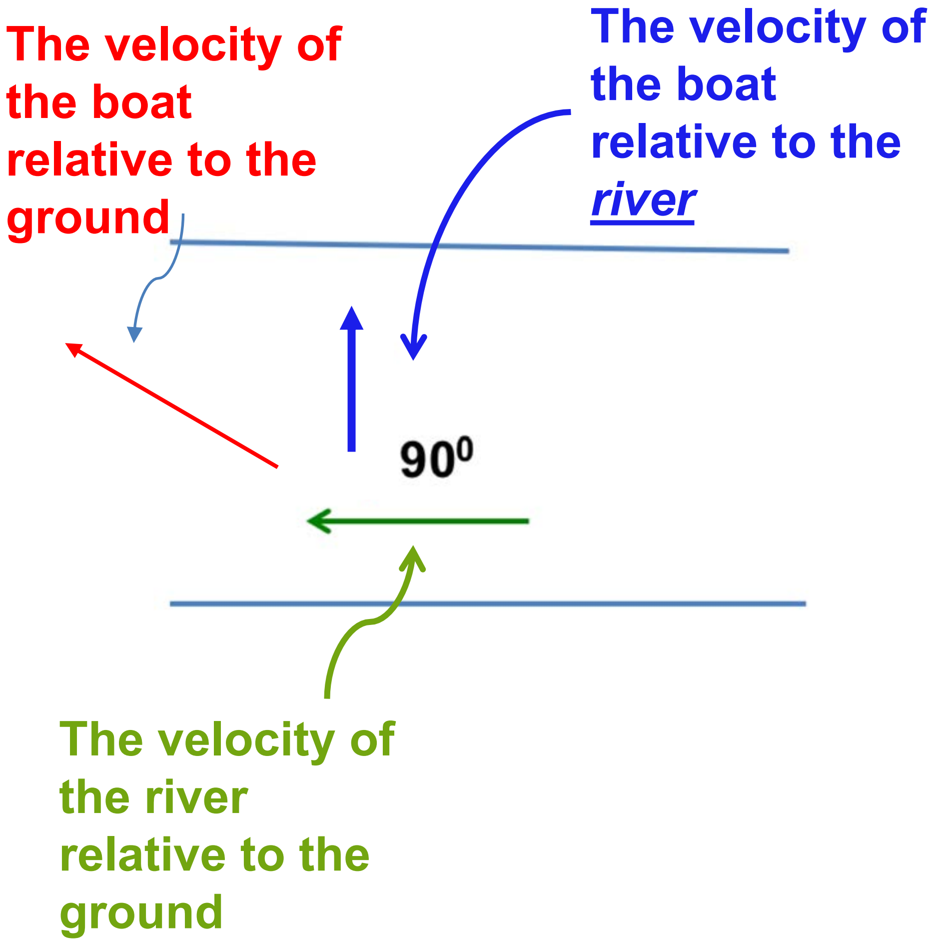


$$\boxed{\vec{V}_{BG} = \vec{V}_{BR} + \vec{V}_{RG}} \qquad \vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

Crossing river by the shortest *path*

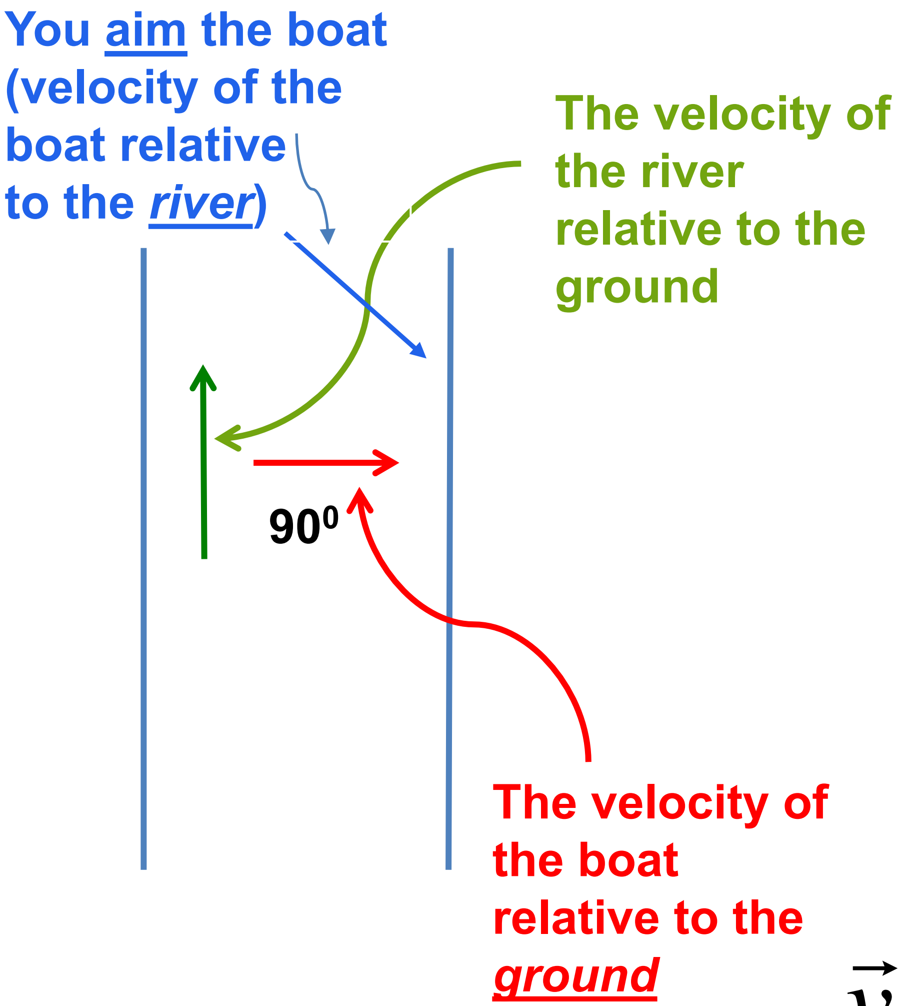


Crossing river by the shortest *time*

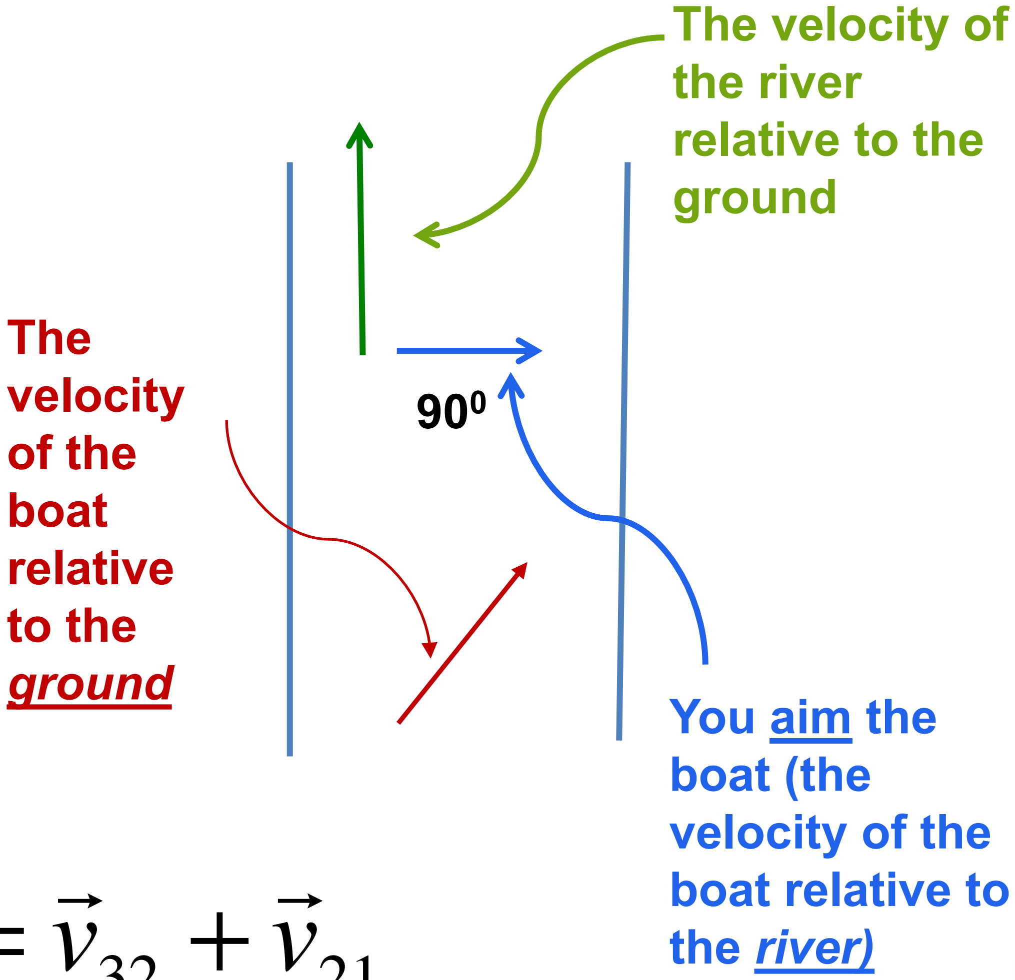


CP2

Crossing river by the shortest *path*

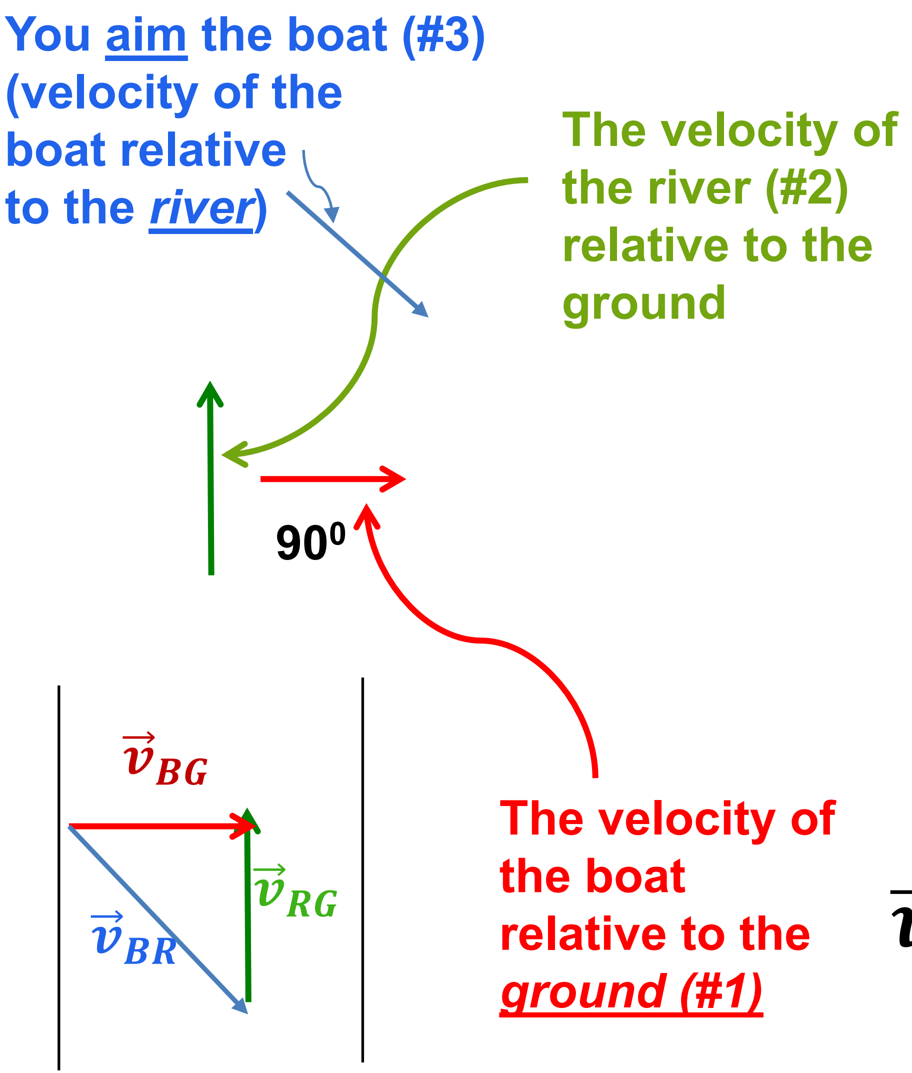


Crossing river by the shortest *time*

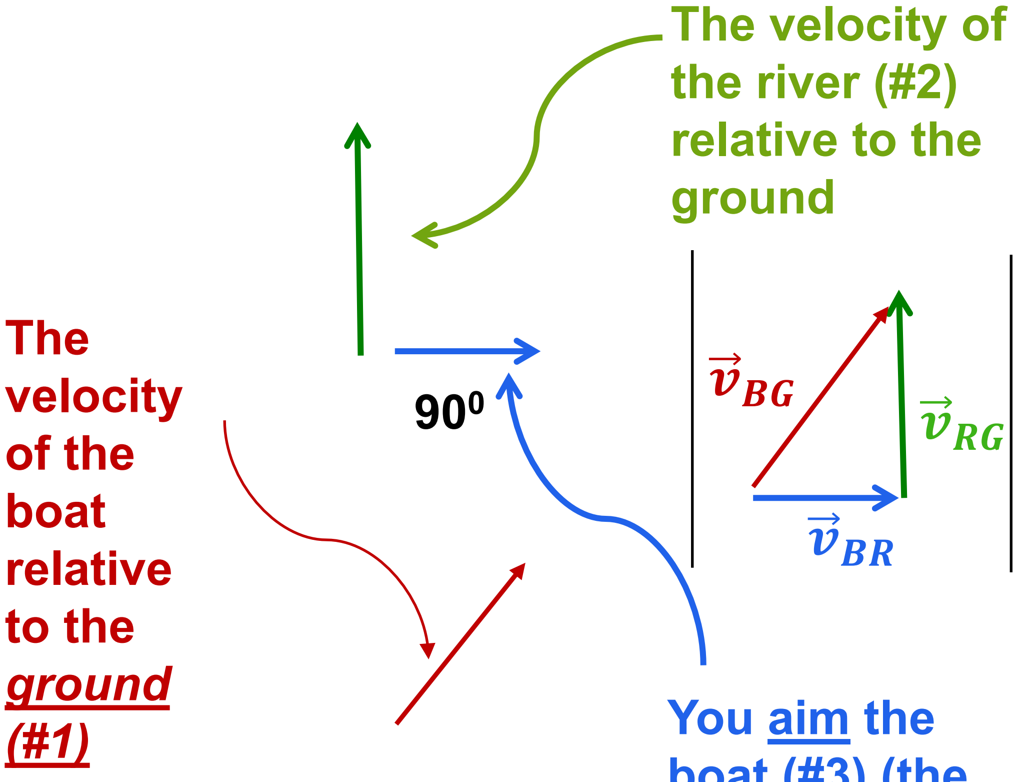


$$\vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

Crossing river by the shortest *path*



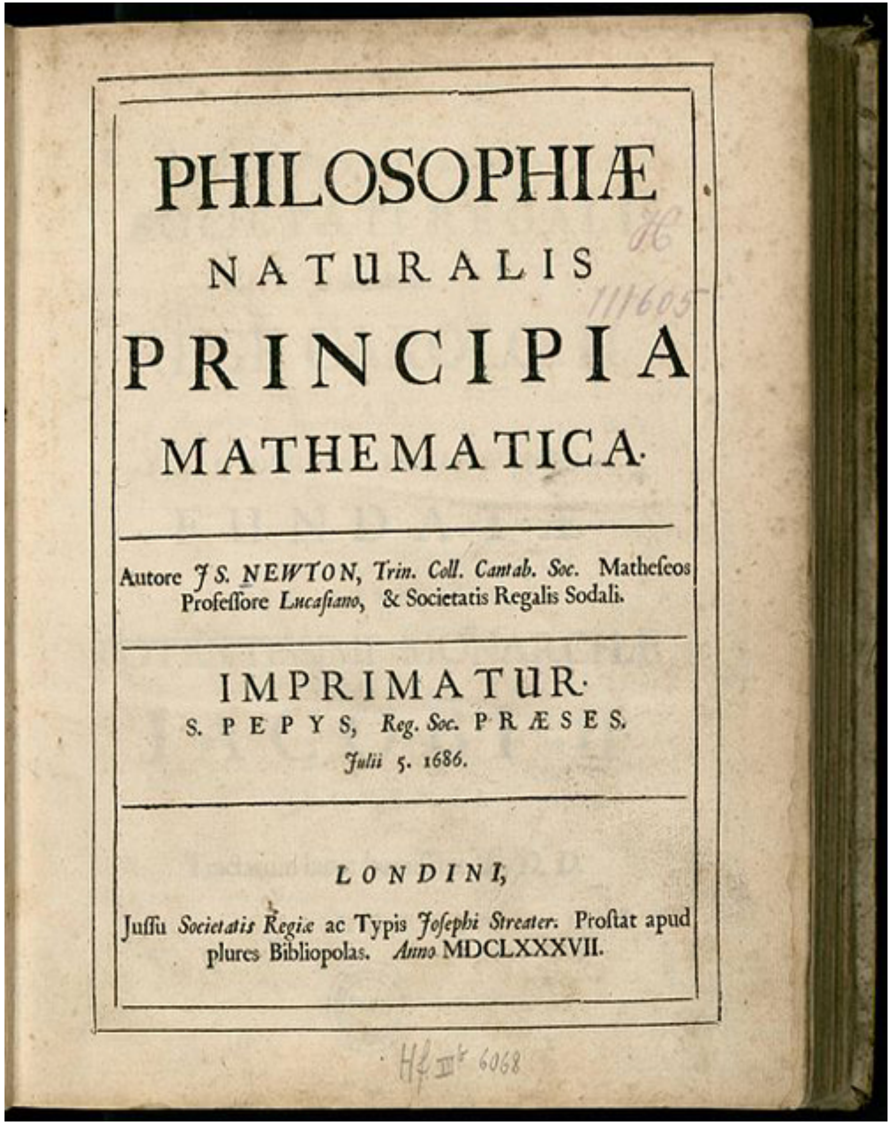
Crossing river by the shortest *time*



$$\vec{v}_{BG} = \vec{v}_{BR} + \vec{v}_{RG}$$

$$\vec{v}_{31} = \vec{v}_{32} + \vec{v}_{21}$$

Dynamics



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

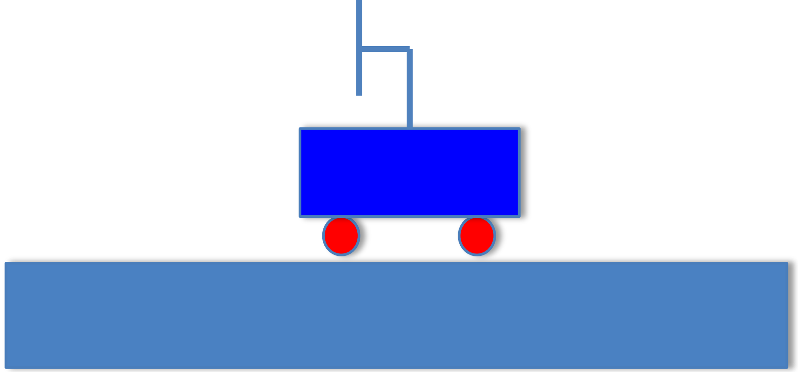
Isaac Newton's monumental work, *Philosophiae Naturalis Principia Mathematica*, was published in **1687**. It proposed scientific laws that are still used today to describe the motion of objects. (credit: Service commun de la documentation de l'Université de Strasbourg)

A ***force*** is a push or a pull.

Force is a measure of interaction

Contact forces arise from physical contact **("touching" = "interacting")**

Action-at-a-distance forces do not require contact and include gravity and electrical forces.



Some of the Mechanical Forces:

1. Gravity; close to the Earth $|F_g| = m*g$
2. Normal force; N = force acting from the support perpendicularly to the surface of the support
3. Tension; T = force in a rope/string (an applied force; a pull)
4. A push – an applied force
5. Elastic force

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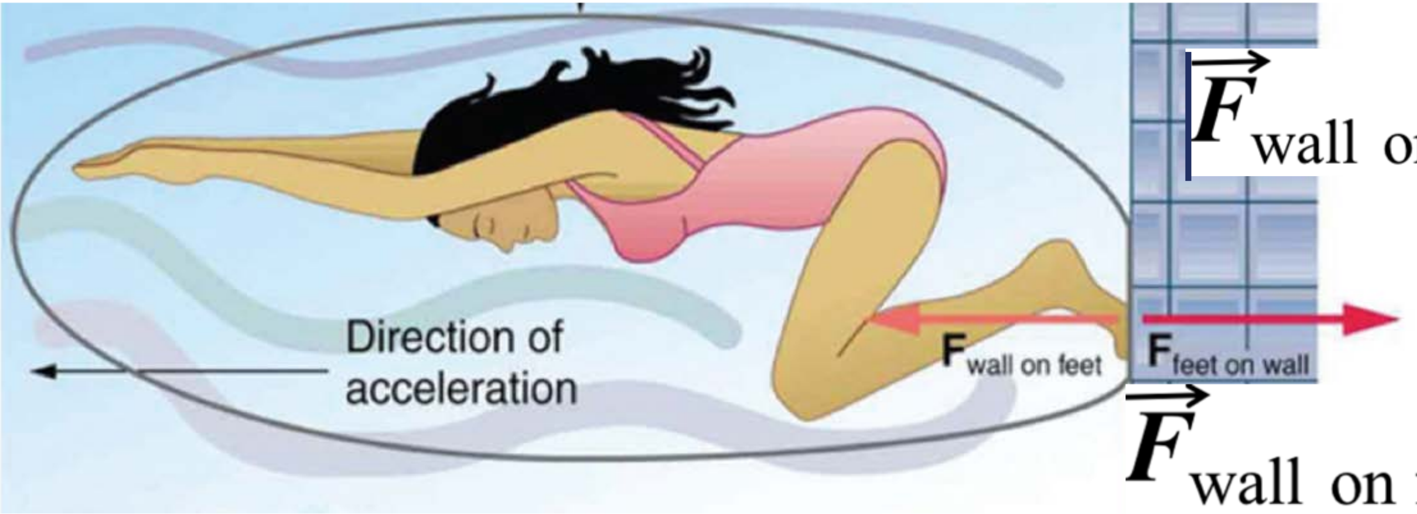
5. Elastic force

EVERY FORCE HAS A SOURCE!

A force acting on an object comes from another object, which, in turn, experiences a force acting back from the first object. => INTERactions!

Newton's third law

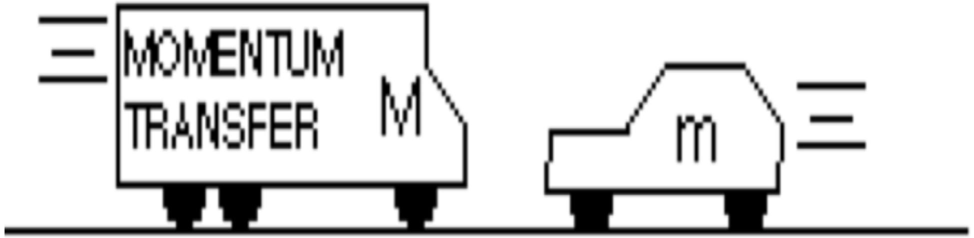


$$\left|\vec{F}_{\text{wall on feet}}\right| = \left|\vec{F}_{\text{feet on wall}}\right|$$

$$\vec{F}_{\text{wall on feet}} = -\,\vec{F}_{\text{feet on wall}}$$

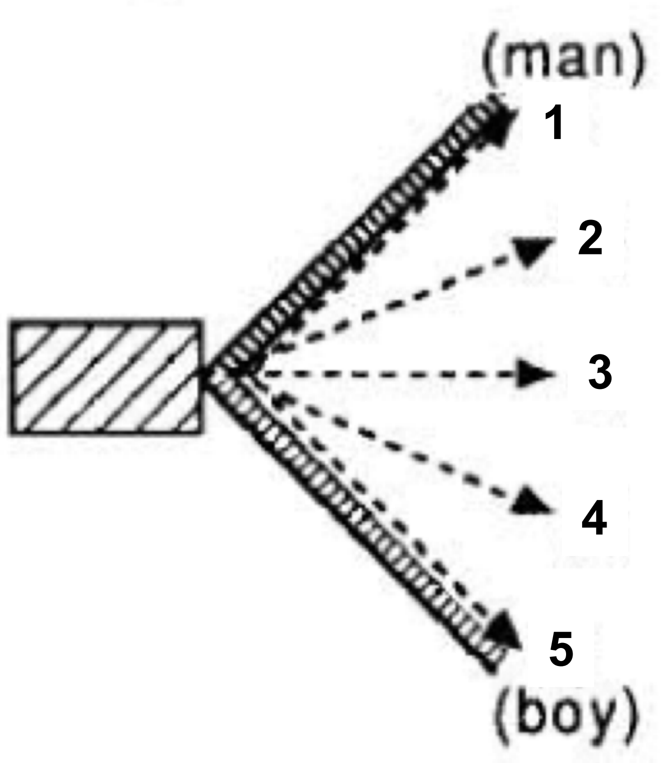
When the swimmer exerts a force $\vec{F}_{\text{feet on wall}}$ on the wall, in accordance with **Newton's third law**, the wall exerts a force $\vec{F}_{\text{wall on feet}}$ on her, **equal in magnitude but in the direction opposite** to the one she exerts on it.

$$\overrightarrow{F_{12}} = -\overrightarrow{F_{21}}$$



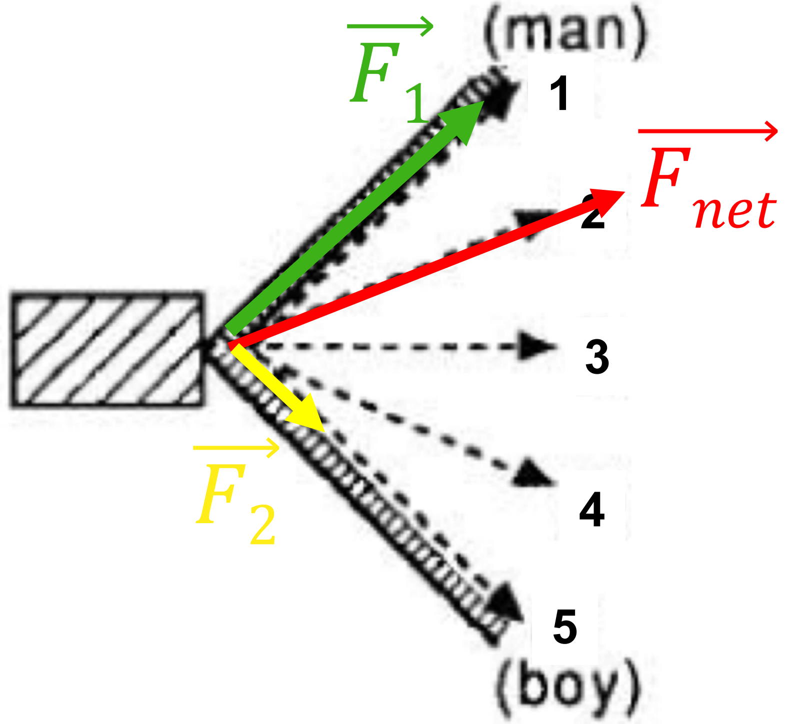
N3L: The amount of force A exerts on B is equal to that of the B exerts on A.

LectureMCQ L6 Q5

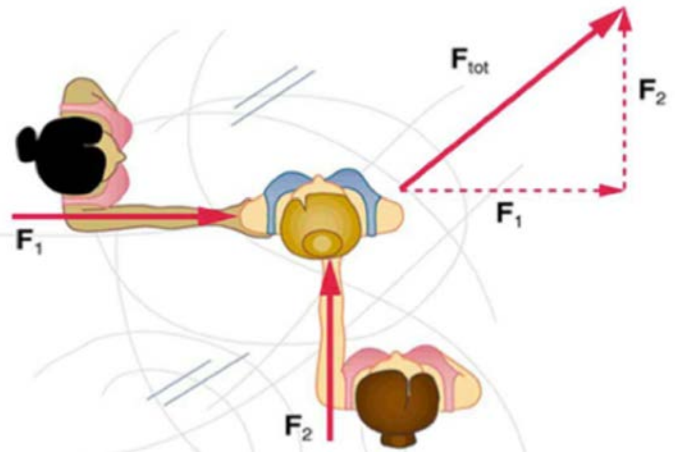


Two people, a large man and a boy, start pulling as hard as they can on two ropes attached to a crate as illustrated in the diagram to the left. Which of the indicated paths (1- 5) would most likely correspond to the path of the crate as they pull it along?

Two people, a large man and a little boy, *start* pulling as hard as they can on two ropes attached to a crate as illustrated in the diagram to the left. Which of the indicated paths (1- 5) would most likely correspond to the path of the crate as they pull it along?



$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \dots$$



The *net force* is the vector sum of all of the forces acting on an object.

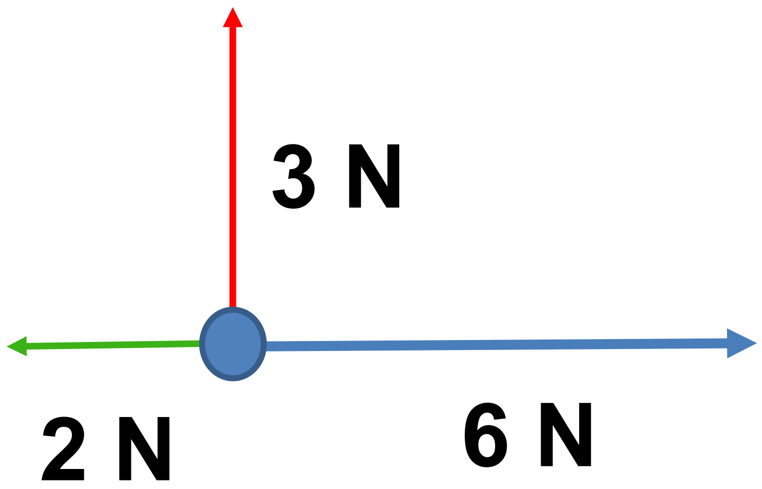
Mathematically, the net force is written as

$$\boxed{\sum \vec{\mathbf{F}} = \vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots}$$

where the Greek letter sigma denotes the vector sum.

Some of the Mechanical Forces:

1. Gravity; close to the Earth $|F_g| = m \cdot g$
2. Normal force; N = force acting from the support perpendicularly to the surface of the support
3. Tension; T = force in a rope/string (an applied force; a pull)
4. Elastic: $|F_e| = k \cdot |\Delta x|$
5. A push – an applied force



Calculate the magnitude of the the *net* force.

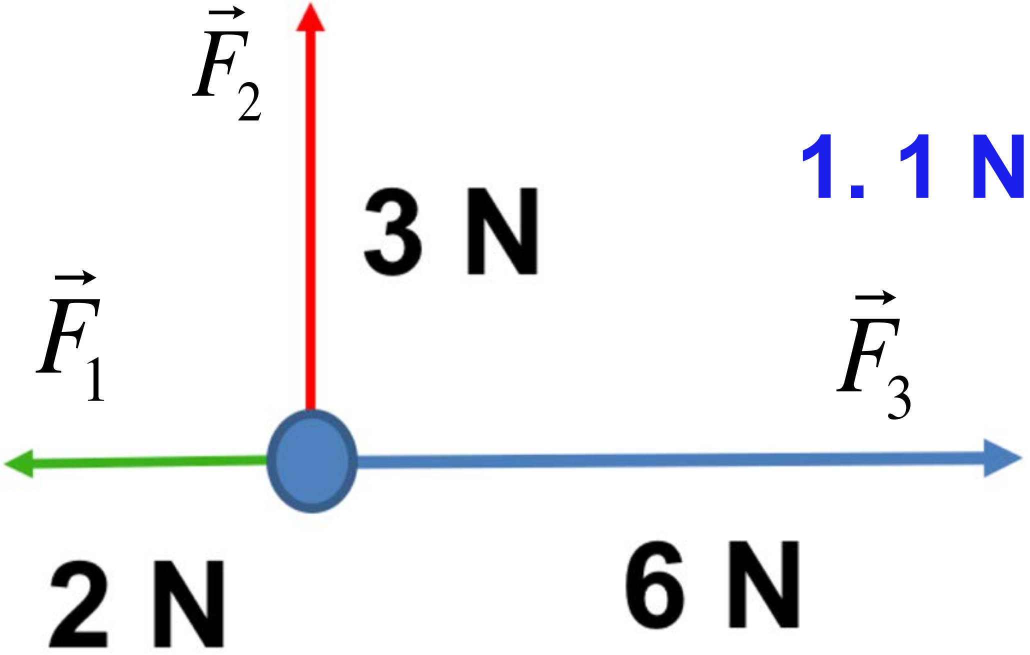
$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots$$

LectureMCQ_L6 Q6

1. 1 N
2. 2 N
3. 3 N

Etc.

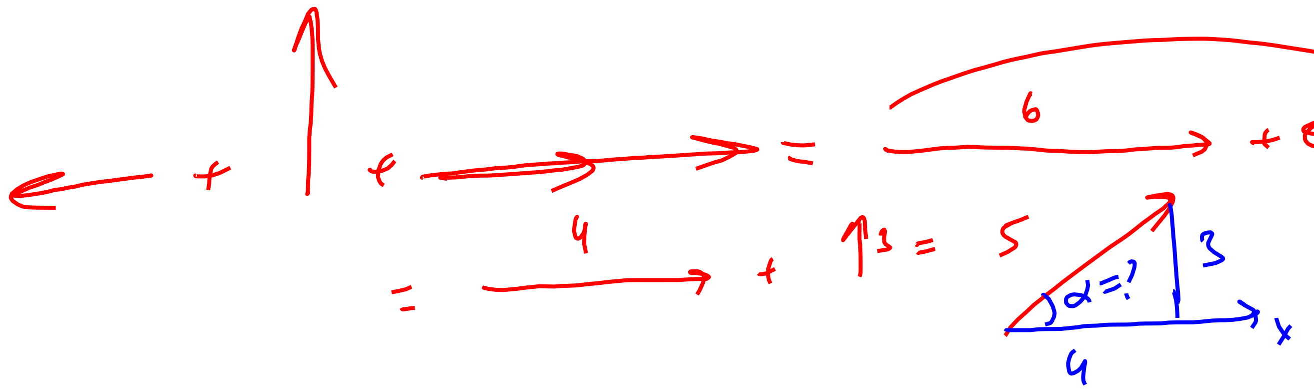
LectureMCQ L6 Q6



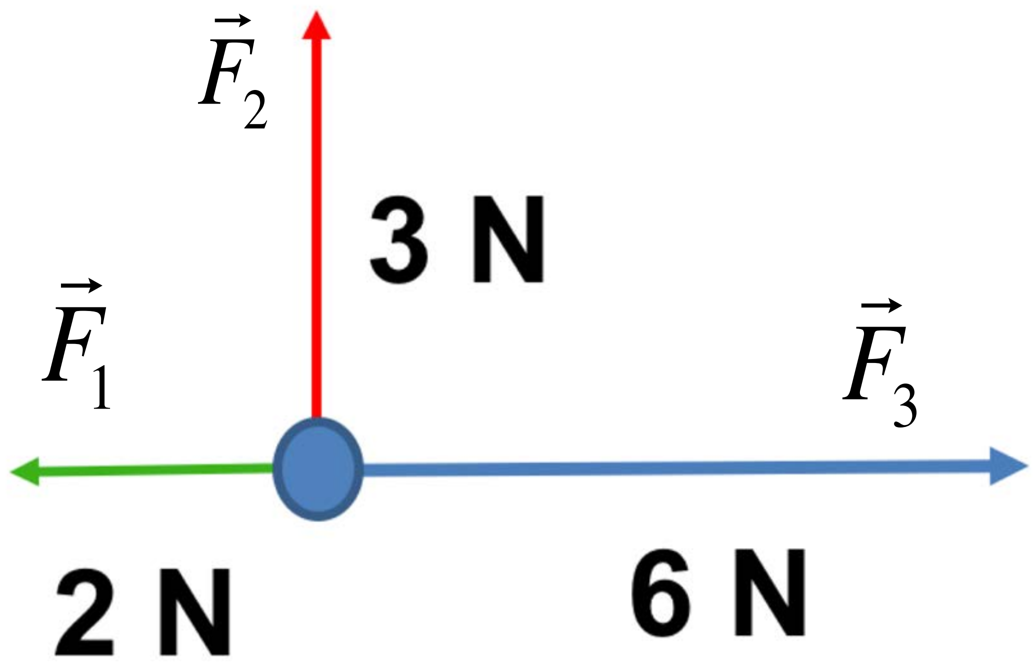
1. 1 N 2. 2 N 3. 3 N Etc.

$$\vec{F}_{Net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$$

$\cancel{\| = 2 + 3 + 6}$ WRONG



$\alpha = \tan^{-1}\left(\frac{3}{4}\right) \sim 37°$



$$\vec{F}_{Net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$$

$$|\, F_{net} \,| = 5\ \text{N}$$

A FORCE is a result if an INTERACTION between **2** objects!

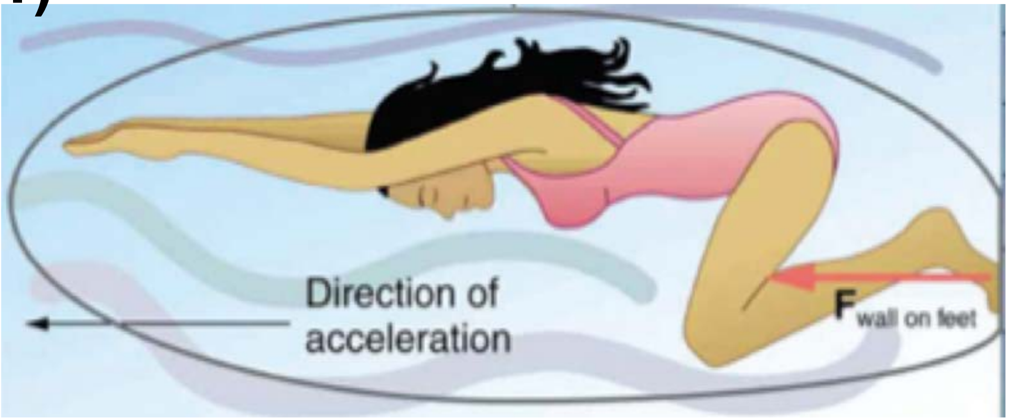
EVERY FORCE HAS A ***SOURCE***!

A ***specific*** object

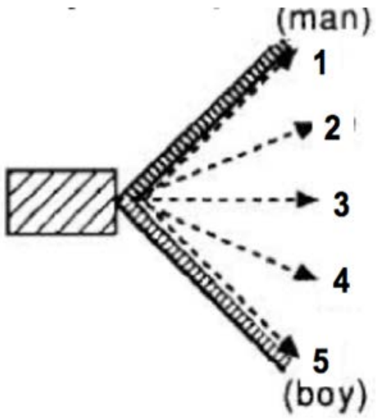
BUT….

A Free Body Diagram (FBD) => show forces!

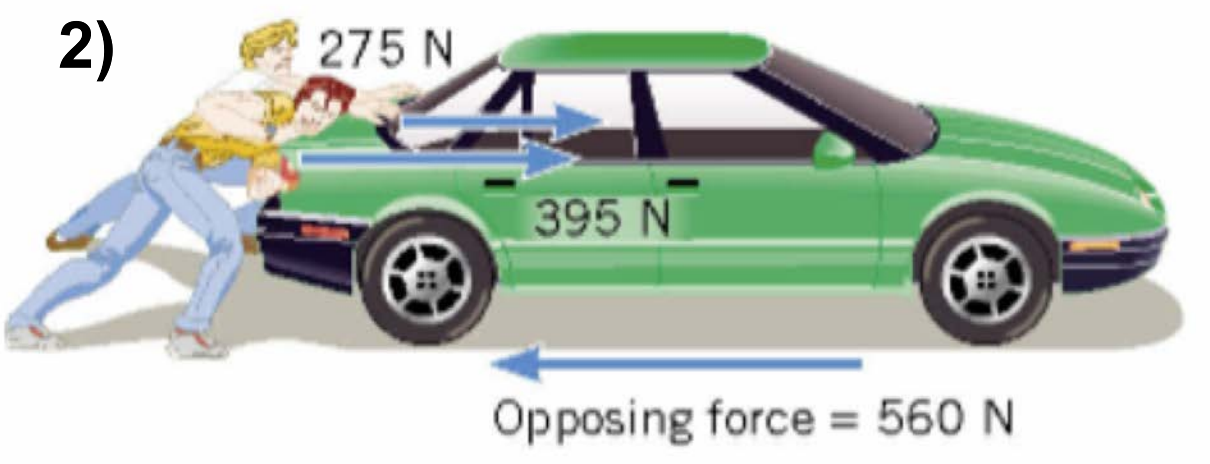
1)



3)



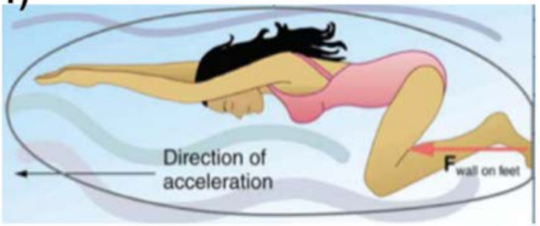
2)



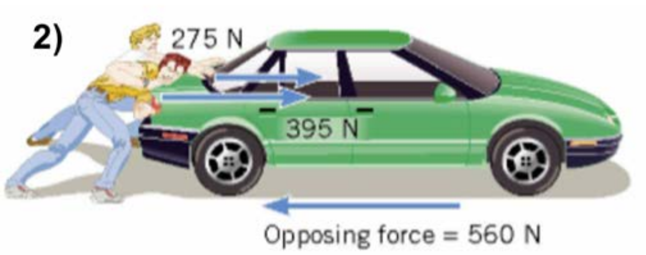
4)

FBD

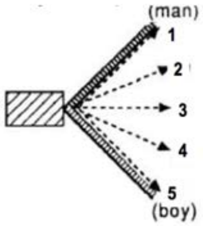
1)


Direction of acceleration
$F_{\text{wall on feet}}$

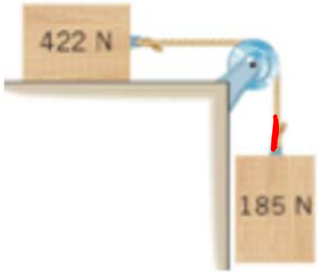
2)

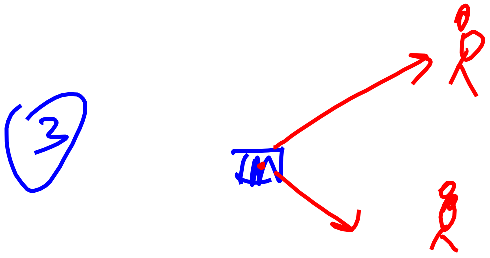

275 N
395 N
Opposing force = 560 N

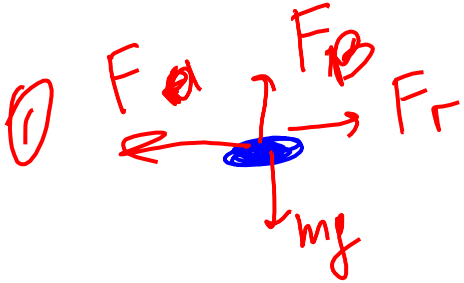
3)

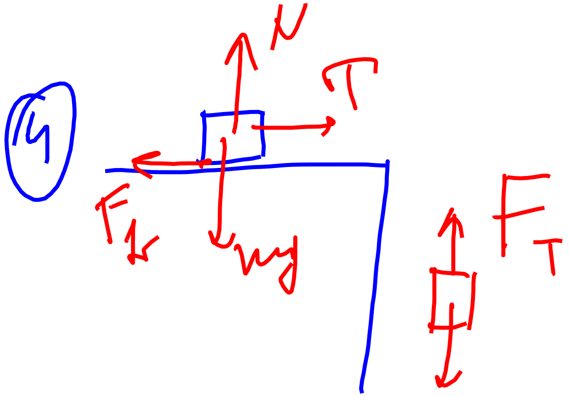

(man)
1
2
3
4
5
(boy)

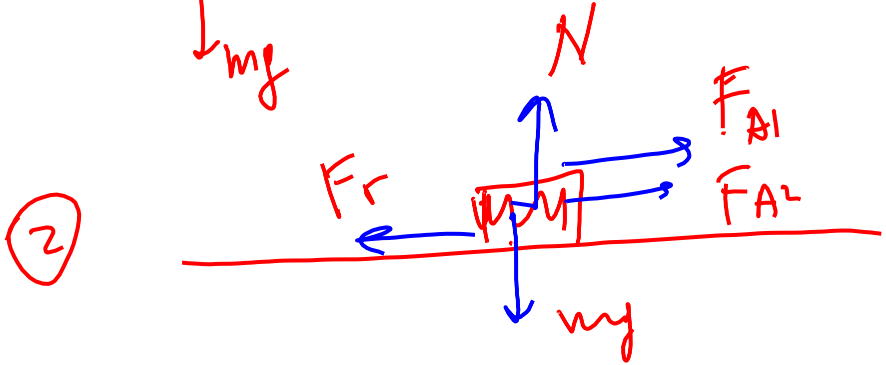
4)


422 N
185 N


3


1
F_A
F_B
F_r
mg


4
N
T
F_r
mg
F_T


2
N
F_{A1}
F_{A2}
F_r
mg

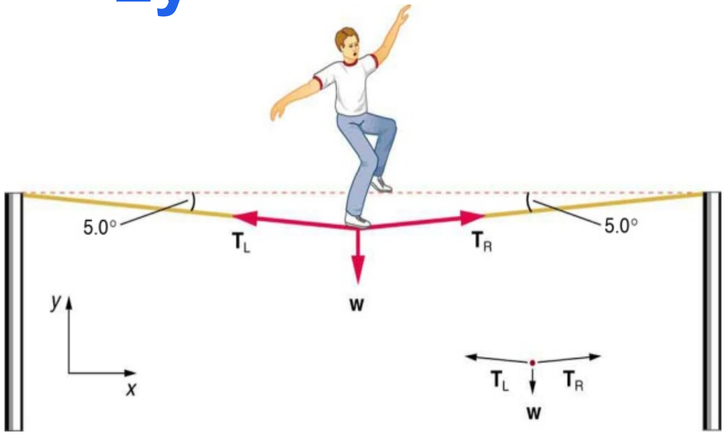
When forces are acting on an object =>

(A) Equilibrium

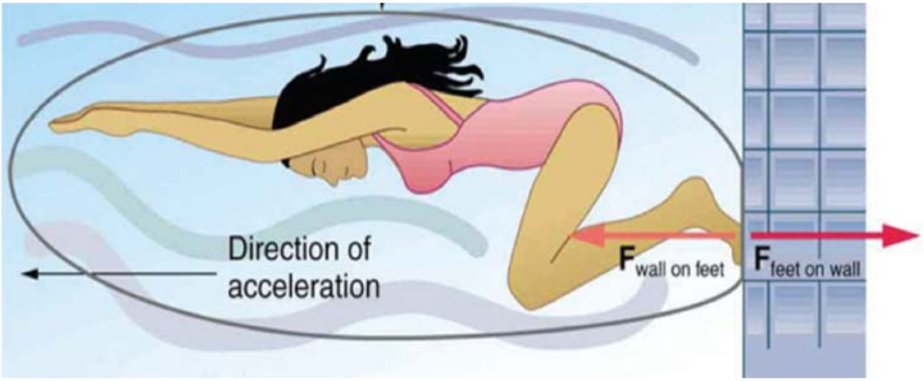
$$\vec{F}_{net} = 0 \text{ (and } \vec{v} = 0\text{)}$$

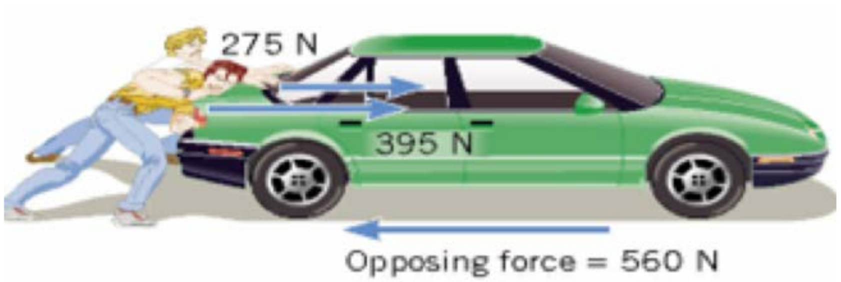
$$F_{1x} + F_{2x} + \ldots = 0$$

$$F_{1y} + F_{2y} + \ldots = 0$$

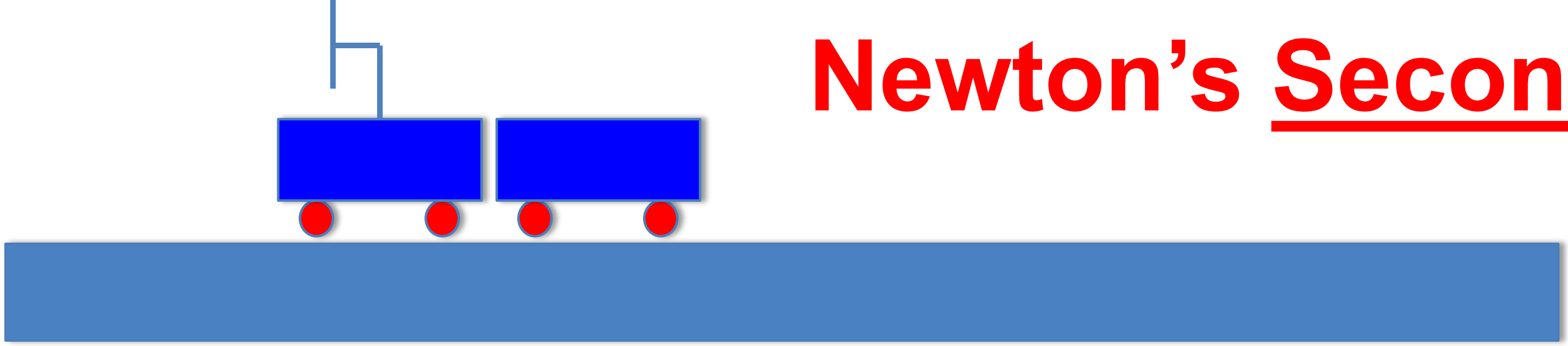


(B) $\vec{F}_{net} \neq 0$

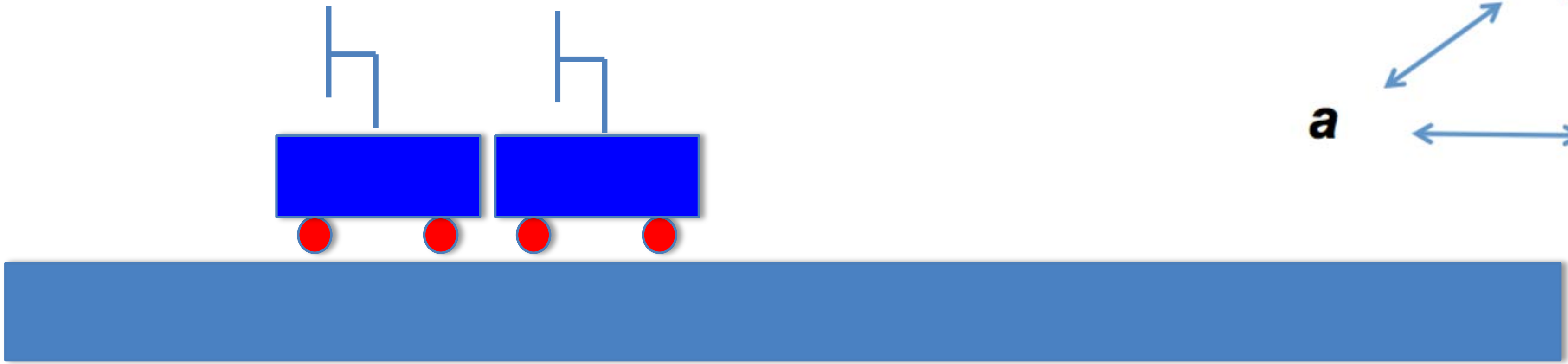


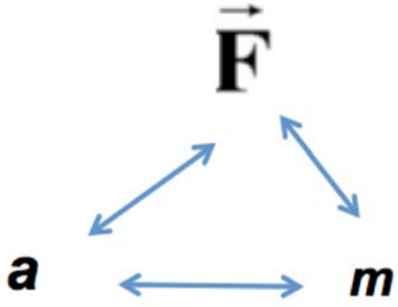


Newton's Second Law



vs.

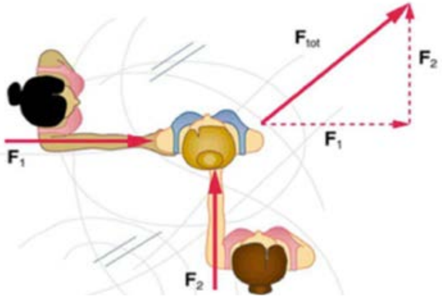




$$a \propto F \qquad a \propto \frac{1}{m}$$

$$\sum \vec{F} = \vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots$$

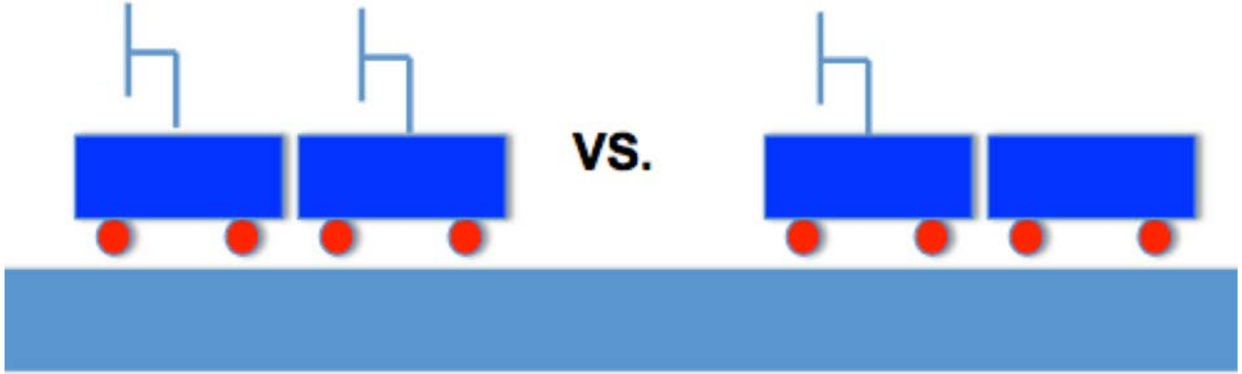
<u>**N2L**</u>



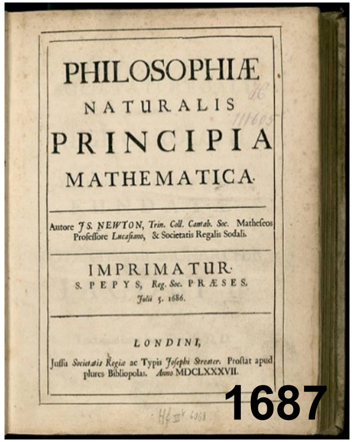
$$\boxed{\vec{a} = \frac{\sum \vec{F}}{m}}$$

$\vec{F}_{Net}$

a $\leftrightarrow$ m



$$a \propto F \qquad a \propto \frac{1}{m}$$


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.
Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.
IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.
LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

1687

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \ldots$$

Some of the Mechanical Forces:

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4. Elastic: $|F_e| = k \cdot |\Delta x|$
5. A push – an applied force

The Newton's Second Law (N2L)

$$\boxed{\vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m}}$$

The acceleration of an object (a.k.a. *system*) is equal to the net force acting on the object divided by the mass of the object.